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Fieberling Guyot Studies

Final Report Prepared
for the Office of Naval Research
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for Grant N00014-89-J-1054
for the Period 10-01-88 - 04-30-91
Principal Investigator: Peter F. Lonsdale

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The work under this grant concentrated on interpreting ocean-floor geomorphology, especially by fine-scale studies of sites where relief is being actively created or modified, by tectonism and volcanism (e.g. at plate boundaries and young seamounts) or by bottom current activity. An important focus of the latter aspect was to learn how to use deep-sea bedforms (the clearest evidence of geologically effective bottom currents) to infer characteristics of the forcing flow and the benthic boundary layer, as well as for delineating rates and routes of sediment transport.

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Peter F. Lonsdale (Principal Investigator)

OBJECTIVE

The work under this grant concentrated on interpreting ocean-floor geomorphology, especially by fine-scale studies of sites where relief is being actively created or modified, by tectonism and volcanism (e.g. at plate boundaries and young seamounts) or by bottom current activity. An important focus of the latter aspect was to learn how to use deep-sea bedforms (the clearest evidence of geologically effective bottom currents) to infer characteristics of the forcing flow and the benthic boundary layer, as well as for delineating rates and routes of sediment transport.

BACKGROUND

Fieberling was first described by Carsola and Dietz (1952) as a extinct volcano 500 miles west of San Diego, with a wave-planed summit now 500-700 m below sea-level. Since 1983 several collections of Seabeam swaths across Fieberling and an isotopically dated lava sample (20 Ma), were conducted as part of an ONR-funded study of seamounts off southern California. Many of these seamounts lie in a hotspot chain which has Fieberling as its oldest member, and Guadalupe as the only other volcano which grew above sea-level, though the summits of several others (Hoke, Stoddard, Jasper) were once within a few hundred meters of the sea surface.

In 1986 a 4-day Deep Tow survey of the 70 km^2 summit plain of Fieberling Guyot was conducted, funded by an ONR 6.2 contract with definition of the near-bottom magnetic field as its primary purpose. Ancillary geologic and biologic observations were made with the sonars and stereo cameras of the Deep Tow vehicle, and near-bottom currents were measured by attaching current meters to the navigational transponder moorings.

APPROACH

The project included a field experiment to monitor the migration of fields of cohesionless sand bedforms (ripples and larger-scale waves) at 600 m depth on the surface of Fieberling Guyot. Bottom currents and benthic boundary layer physics and biology were measured during this experiment by current meters, CTD profiles,

and BASS (Benthic Acoustic Stress Sensor) tripods. The first year of the project was devoted mainly to survey operations that were essential for site selection and problem definition for this project.

First-Year Field Program

A 5-day surface ship survey, navigated by GPS plus Loran C, provided a complete Seabeam bathymetric map of the guyot side-slopes and base, complementing the existing Deep Tow bathymetry of the summit. At the same time as the Seabeam survey, a Sea MARC II survey was made, 3.5 kHz acoustic profiles were taken (mainly to look for evidence of current scour around the base of the volcano and its satellite cones) and the gravity and magnetic field was measured.

Complete high-resolution bathymetry was a prerequisite for many of the studies in the topographic interactions program. The bathymetric data was used in a quantitative comparison of the geomorphology of guyot side-slopes with the slopes of similar but never-emergent volcanoes in the chain which have already been completely surveyed by Seabeam (e.g. Jasper Seamount). During the bathymetric survey amplitude data from the Seabeam system was processed and displayed for quantitative acoustic studies of bottom reverberation and of the Deep Scattering Layer (by Christian de Moustier).

The gravity field was measured with *Washington's* new Bell gravimeter to provide precise definition of the marine geoid, needed for full interpretation of time-varying (oceanographic) information from satellite altimetry. The guyot's gravity field was also used to interpret the density distribution (and hence the internal structure) of the volcano, using inversion techniques. Gravity-derived inferences about the internal structure were valuable because guyot planation had already exposed shallow parts of the interior (down to about 1 km below the former volcano surface), so geologic inference (downward extrapolation of known dike and plug structures) helps interpret the density distribution. Magnetic data was also inverted to define magnetization distributions and hence help interpret the internal structure.

Second-Year Field Program

The MPL Deep Tow system was used for further near-bottom study of the guyot. A survey on the western part of the summit plain concentrated on photographic mapping of current bedforms on previously located sand patches. In addition to a more thorough Deep Tow survey of part of the summit, a sector of the guyot's side slopewe was acoustically mapped and photographed. This characterized the slope's steepness, small-scale roughness, surface composition (bare rock, cobbles, talus, sand, mud) from the shelf break to the foot of the volcano.

Investigation of ripple and sand wave migration over the summit plain was an integral part of the benthic boundary layer study that was a major component of the ONR Applied Research Initiative. Success of this study was dependent on collaboration with other investigators simultaneously measuring the fluctuations of current and shear stress in the free flow and boundary layer; conversely, appreciation of the bed geometry and mobility is required for interpretation of the boundary layer physics and ecology and distribution of the benthic infauna.